EXECUTIVE SUMMARY
LOWER PASSAIC RIVER STUDY AREA
FEASIBILITY STUDY

The Lower Passaic River Study Area (LPRSA) Cooperating Parties Group (CPG) has been conducting the remedial investigation and feasibility study (RI/FS) for the 17.4-mile Lower Passaic River (LPR) since 2007 under U.S. Environmental Protection Agency (EPA) oversight. The CPG provided funding for the 17-mile RI/FS activities performed by EPA from 2004 to 2006 and subsequently assumed responsibility for its completion, in an effort that has involved the collection and evaluation of more than 12,000 sediment, water, and biota samples and total study costs of approximately $130 million to date. This feasibility study builds on the integrated understanding of the system characteristics, nature and extent of contamination, and risks posed to human health and the environment, described in the 17-mile LPRSA remedial investigation report and the supporting baseline human health and ecological risk assessments. The findings from these investigations and evaluations are the foundation for developing and evaluating remediation strategies in the feasibility study to best achieve risk reduction objectives for the entire LPRSA.

The size and complexity of the LPRSA create unprecedented challenges for selecting and implementing an active sediment remedy that is protective of human health and the environment, technically and administratively feasible, and cost-effective, as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (also known as the National Contingency Plan [NCP]). Many of these challenges arise from the highly urbanized and densely populated setting of the LPRSA, the changing characteristics of the LPR over its length, the existence of many physical constraints to implementing an active sediment remediation project on the LPR (e.g., bridges and shoreline structures, utility crossings, debris, presence of hardpan and rock outcrops), navigational challenges, seasonal restrictions on remediation activities. Additionally, the continuation of ongoing sources of contamination to the LPR from above Dundee Dam and by tidal exchange with Newark Bay will limit recovery of the river. The feasibility study draws extensively from information and lessons learned from early remedial actions implemented on the LPR, as well as experience from other complex sediment sites around the country. The CPG has also undertaken several other supporting evaluations (e.g., a quantitative evaluation of the short-term impacts of implementing a cleanup on the local community and the environment, a processing facility siting evaluation, a waterway conditions assessment, and an evaluation of navigational factors for dredge, barge, and tugboat operations) that inform various aspects of the feasibility evaluation. These evaluations are documented in the feasibility study and its technical appendices.

All of the active remedial alternatives under consideration for the LPR involve removal, transport, and disposal of very large quantities of sediment contaminated with

2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), polychlorinated biphenyls (PCBs) and other chemicals. The largest remedial alternatives considered in this evaluation will take decades to construct, during which they will adversely impact the community's quality of life and will require a massive commitment of financial and natural resources to implement. Large-scale sediment remediation projects, especially in an environment as challenging as the LPRSA, involve significant uncertainties with respect to technical implementation, construction time frames, cost, and the effectiveness of the remediation in promoting recovery of the system to reduce risk to human health and the environment. These circumstances call for the application of adaptive management as a component of the selected remedial action, as recommended by EPA guidance, the National Research Council, and other independent, scientific peer reviews of sediment sites throughout the country. As stated in EPA's 2002 guidance, *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites,* Sediment Management Principle 5:

> *"EPA encourages the use of an iterative approach, especially at complex contaminated sediment sites. As used here, an iterative approach is defined broadly to include approaches which incorporate testing of hypotheses and conclusions and foster re-evaluation of site assumptions as new information is gathered."*

Adaptive management is compatible with phased remediation approaches that allow for an iterative evaluation of progress toward remedial goals, recognize project-related uncertainties and risks of implementing a large remedy at a complex site (including the limitations of accurately predicting recovery), and involve responding actively to new information and conditions during the remedial process. This systematic remedial approach promotes the efficient use of resources and reduces short-term impacts on surrounding communities. Adaptive management can assure the success of remedial actions, since progress is routinely assessed by comparing remedy performance with performance goals, allowing for actions to be adjusted, when needed, to address up-to-date environmental conditions.

A targeted remediation approach for the 17.4-mile LPRSA, which is reflected in Alternative 2 of this feasibility study, is more consistent with adaptive management than the bank-to-bank remediation approach reflected in Alternatives 3 and 4. Targeted remediation will address the areas of highest contamination that contribute most significantly to risk and that are inhibiting natural recovery, thereby achieving rapid risk reduction and enhancing natural recovery in non-targeted areas, with far lesser impacts on the community and the environment than bank-to-bank remediation. This approach takes advantage of the refined conceptual model developed in the remedial investigation of current environmental conditions and the distribution of contamination in the LPR, and allows for managing uncertainties and adapting the remedy based on new information and future conditions, if necessary, to achieve the risk reduction objectives. By contrast, the bank-to-bank alternatives attempt to manage uncertainties in the implementation and effectiveness of a large sediment remedy by moving directly to a complete removal, providing no opportunity to modify the remedy based on information obtained during its implementation.

KEY FINDINGS FROM THE REMEDIAL INVESTIGATION

The 17.4-mile LPRSA begins at Dundee Dam and ends at Newark Bay (Figure ES-1). Freshwater and solids enter the LPR from the watershed are dominated by the inflow from the Upper Passaic River (UPR) at Dundee Dam. Several tributaries also flow into the LPR. The LPR receives brackish water and solids from Newark Bay via tidal exchange and density driven currents, which together with the freshwater flow dictate the movement of sediment within the estuary. A 15.4-mile-long federal navigation channel (FNC) was created in the late 19th century to facilitate industrial activity along the river. The channel between river mile (RM) 1.9 and RM 8.3 was last maintained in or before 1950. The last maintenance dredging in the lower 1.9 miles of the channel was conducted in 1983. Infilling of the navigation channel has occurred to varying degrees since the cessation of maintenance dredging, promoting the trapping of contaminants in LPR sediment, with the most extensive infilling downstream of RM 8.

In addition to infilling that followed navigational dredging, sedimentation occurred in the LPR at rates that relate to the river's geomorphology. For example, sedimentation rates were lower on the outer bends and in higher velocity reaches of the river than within the main channel. On inner bends, deposition of silt-sand and muddy sediment formed broad point bars that are significant geomorphological features. The sediment bed is largely stable such that sediment deposited in the 1950s and 1960s have typically remained buried. In some locations such as the mudflats at and upstream of RM 7, deposition has slowed or ceased, leaving sediment deposited in the 1960s at or near the surface. Erosion occurs in places where it is expected; that is, on edges of the channel, downstream of bridge abutments, in areas of constricted cross-section, and in the more sinuous portions of the lower 5 miles. Erosion has been generally modest and many of these areas are subject to infilling between high flow events.

A variety of contaminants, including 2,3,7,8-TCDD, PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs), mercury, and other metals have been identified in LPR sediment and the water column. Many of these contaminants have entered the food web and bioaccumulated in tissues of benthic invertebrates, fish, and crab. The concentration patterns for many of these contaminants tend to mirror one another in sediment downstream of RM 14, particularly for 2,3,7,8-TCDD, total PCBs, and pesticides (and to a lesser extent mercury and PAHs). A key finding of the remedial investigation is that the contamination follows predictable spatial and temporal patterns that reflect the evolution of the river's sediment deposits, the nature of the sediment, well-understood erosion, deposition and contaminant fate and transport processes, and interactions between the sediment and biota. The patterns of contamination in sediment and knowledge of the underlying physical and chemical processes provide a basis for identifying areas that are recovering naturally and those that are recovering slowly or not at all. These conditions allow for targeted, active remediation strategies to be developed that will achieve risk reduction objectives most effectively.

For many contaminants (PAHs, mercury, and pesticides) surficial sediment concentrations within the LPRSA are similar to regional background observed upstream of Dundee Dam and downstream of the LPR in Newark Bay. Contamination that enters the LPR from these external sources limits recovery in the absence of remediation and may recontaminate remediated areas.

Human health risk in the LPRSA is driven primarily by exposure to 2,3,7,8-TCDD, and to a lesser extent by PCBs. Fish and crab consumption risks from other contaminants of concern (COCs) are relatively minor and comparable to background. Contaminants enter the food web primarily from exposure of the benthic invertebrate community to contamination in the biologically active zone of near-surface sediment (i.e., almost exclusively within the top 2 centimeters of the sediment bed) and subsequently bioaccumulate in the tissue of fish and crab. To reduce contaminant levels in fish and crab tissue, remediation should focus on reducing contaminant levels in surface sediment that directly impact the food web. Remediating high concentrations in surface sediment can immediately reduce risks to human health and the environment and provide further long-term risk reduction by reducing contaminant concentrations on resuspended and depositing particles, thereby accelerating the decline of surficial contaminant concentrations in other areas. Targeting sediment areas that are not recovering, have relatively high contaminant concentration in the top few centimeters, and are inhibiting the overall recovery will provide the most rapid risk reduction and accelerate the recovery of the river while limiting impacts to the river's ecology and surrounding communities.

SUMMARY OF SITE RISKS

Consumption of fish and crab constitutes the primary source of human health risk. Direct exposures to surface water and sediment do not pose risks to humans in excess of target risk levels, with the exception of accessible surface sediment in the RM 6 to 9 area (particularly the east bank). The primary human health risk driver is 2,3,7,8-TCDD, and the secondary is PCBs. Contribution to risk from other compounds, including several pesticides, PAHs, and metals, are relatively minor and comparable to background. The composition of the fish diet consumed by humans has a significant bearing on the magnitude of risk. Some fish species exhibit greater tissue burdens of the primary COCs than others; a diet that includes the common carp (a nonnative invasive species) along with the four other consumed species (white perch, American eel, channel catfish, and largemouth bass) poses potential risks as much as fourfold higher than a diet without carp. Similarly, a crab diet that includes consumption of the hepatopancreas (green gland), as well as muscle tissue, poses potential risks that are five- to six-fold higher than a more typical diet of muscle tissue only.

Consistent with EPA Region 2 directives, extremely conservative assumptions were selected for the baseline human health risk assessment (BHHRA). Many of these assumptions were represented by upper bound values of exposure parameters. These included the assumptions that a person would eat as many as 56 adult fish meals per year, that fish consumption would continue for 30 years, that all of the fish consumed would be from the LPRSA, and that there would be no loss of contaminants during cooking. When all of the conservative assumptions are compounded, human health risks are, by definition, overestimated. Actual exposures based on a thorough understanding of site-specific conditions are likely much lower than suggested in the BHHRA. Using assumptions that are reasonably conservative and more accurately reflect site-specific conditions yield risks approximately tenfold lower than those presented in the BHHRA.[1]

Even using the extremely conservative assumptions mandated by EPA Region 2, the potential for unacceptable risk to ecological receptors based on exceedances of thresholds is limited to exposure to polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), PCBs, and to a much lesser extent methylmercury (for which LPRSA fish tissue levels appear to be at regional background levels). However, actual adverse effects from these contaminants on fish, bird, or mammal species are not predicted in the baseline ecological risk assessment (BERA), based on the low level of threshold exceedance (hazard quotients slightly greater than 1), the conservatism of the assessment (e.g., assumption of 100 percent of site use by species known to be migratory), the lack of actual use of the site by some receptors considered (e.g., otter and mink), and the use of other conservative assumptions in the BERA. Further, benthic community impairment shows little correlation with sediment contaminant levels, and, with few exceptions, is not greater than observed at background locations. Non-chemical characteristics such as organic carbon, salinity, and sediment grain size likely contribute to impairment of the benthic community.

REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

Remedial action objectives (RAOs) briefly describe what a remedial action under CERCLA is expected to accomplish, taking into account the scope and goals of the CERCLA program, legal and administrative requirements (applicable or relevant and appropriate requirements [ARARs]), risks evaluated at the site, and background concentrations of COCs in the environment. The proposed RAOs for the 17.4-mile LPRSA are as follows:

- **Human Health—Fish and Crab Consumption:** Reduce cancer risks and noncancer health hazards to humans who eat fish and shellfish from the LPR by reducing dietary exposures to human health risk drivers in edible fish and shellfish tissue.
- **Human Health—Direct Contact:** Reduce cancer risks and noncancer health hazards to humans who come into direct contact with LPR sediment and surface water by reducing concentrations of human health risk drivers in sediment.
- **Ecological Receptors:** Reduce risks to ecological receptors by reducing the concentrations of risk drivers in ecological exposure media.

[1] See AECOM's August 2014 site-specific human health risk assessment of the LPRSA, which was provided to EPA as an attachment the CPG's February 18, 2015, transmittal of the draft remedial investigation report.

- **Surface Water**: Reduce risks to human health and ecological receptors by reducing concentrations of human health and ecological risk drivers in surface water.
- **Contaminant Migration:** Reduce potential contaminant migration from the LPR to Newark Bay by reducing concentrations of risk drivers in surface sediment.

Preliminary remediation goals (PRGs) are used in the feasibility study to evaluate and compare the ability of different remedial action alternatives to achieve CERCLA's primary goals of overall protection of human health and the environment and compliance with ARARs. Based on the results of the BHHRA and BERA and the evaluation of background concentrations in fish tissue, PRGs were established for both human and ecological receptors. For human health, a range of PRGs for 2,3,7,8-TCDD and total PCBs in fish and crab tissue, and for 2,3,7,8-TCDD in sediment, were developed for further evaluation in the LPRSA feasibility study (Table ES-1). PRGs for ecological receptors were evaluated to address potential risks to shorebirds (spotted sandpiper), fish, and mammals (river otter) to ecological COCs. The PRGs take into account the human health and ecological risk-reduction objectives and background concentrations of these COCs.

For human health, the risk-based baseline PRGs were developed to be protective for cancer risks at levels within EPA's acceptable incremental risk range of 1×10^{-4} to 1×10^{-6}, as well as to be protective for noncancer health risks, using the exposure parameters that EPA directed the CPG to apply in the BHHRA, for the reasonable maximum exposure (RME) scenario. Site-specific PRGs (SSPRGs) were also derived based on more realistic, but still reasonably conservative, human health exposure assumptions developed using site-specific information. SSPRGs were developed for 2,3,7,8-TCDD in fish tissue, crab tissue, and accessible surficial sediment, and for PCBs in fish tissue.

Additionally, due to the long time frames expected to meet some of the tissue-based PRGs for consumption of fish and crab under any remedial alternative for the LPRSA, the feasibility study evaluates a set of interim targets to assess progress towards the RAOs (Table ES-1). Interim fish tissue targets were developed for 2,3,7,8-TCDD, as it is the primary human health risk driver and, in contrast to total PCBs, future recovery of 2,3,7,8-TCDD concentrations in fish tissue is not expected to be influenced significantly by background conditions. Interim targets were developed based on a range of alternative fish consumption rates as considered in New Jersey Department of Environmental Protection fish consumption advisories, and are expected to be incorporated into the adaptive management component of Alternative 2. Achievement of interim targets may allow for relaxation of fish consumption advisories prior to achievement of the final remediation goals.

A sediment PRG for 2,3,7,8-TCDD was derived for the spotted sandpiper because the majority of risk to this receptor is through exposure to PCDDs/PCDFs through incidental ingestion of contaminated sediment in mudflats and ingestion of invertebrate tissue. Ecological risks to fish were estimated based on chemical body burdens measured in whole body fish samples. Therefore, tissue-based ecological PRGs were derived for 2,3,7,8-TCDD and total PCBs in fish.

Although methylmercury was identified in the BERA as a COC for fish tissue in the LPRSA, no PRG was developed because LPRSA fish tissue concentrations of methylmercury are not greater than background. Ecological risk-based PRGs for river otter prey were evaluated; however, a PRG was not selected due to the low magnitude of the risk estimate to the otter, the lack of habitat, no known otter or other aquatic mammal use of the LPRSA, and the lack of any realistic ecological population level risk based on the results of the conservative risk estimates in the BERA.

THE REMEDIAL ALTERNATIVES

This feasibility study develops and evaluates remedial alternatives for the entire 17.4-mile LPRSA, including the lower 8.3 miles, in accordance with the administrative order on consent and statement of work for the LPRSA RI/FS. Four remedial alternatives, representing a range of removal volumes, risk reduction, and remedial time frames, are evaluated in this feasibility study:

- Alternative 1: No further action (RM 0 to 17.4)
- Alternative 2: Targeted dredge and cap, monitored natural recovery (MNR), and adaptive management (RM 0 to 17.4), with exposure reduction measures
- Alternative 3: Bank-to bank dredge and cap for RM 0 to 8.3, including reestablishment of the navigation channel from RM 0 to 2.2 (EPA focused feasibility study [FFS] Alternative 3),[2] and MNR for RM 8.3 to 17.4
- Alternative 4: Bank-to-bank dredge and cap for RM 0 to 8.3, including reestablishment of the navigation channel from RM 0 to 2.2, targeted upstream dredge and cap for RM 8.3 to 17.4, and MNR.

Each of the active alternatives (Alternatives 2, 3, and 4) considers two dredged material management (DMM) scenarios:

- DMM Scenario A: transport of dredged sediment via barge to an upland sediment processing facility for dewatering and treatment, followed by off-site disposal of dredged sediment in one or more Subtitle C landfills.
- DMM Scenario B: dredged sediment transported via barge for disposal in a confined aquatic disposal facility to be constructed in Newark Bay.

[2] Separately from the RI/FS, EPA released an FFS in April 2014 that evaluates remedial alternatives to address sediment in the lower 8.3 miles of the river. EPA's FFS emphasizes bank-to-bank approaches to sediment cleanup. In conjunction with the FFS, EPA also issued a proposed plan for the lower 8.3 miles, selecting FFS Alternative 3 (capping with dredging for flooding and navigation) as its preferred alternative, stating it expects this action to "be the final action for the sediments of the FFS Study Area."

Navigational dredging incorporated into Alternatives 3 and 4 is not a CERCLA response action, because it does not address risk to human health and the environment. However, the EPA FFS included reestablishment of the navigation channel from RM 0 to 2.2 as a component of its preferred remedial alternative for the lower 8.3 miles, and that component was included in Alternatives 3 and 4, evaluated in this feasibility study for the 17.4-mile LPRSA, accordingly. Alternatives that result in modification to the FNC depth may require congressional reauthorization or deauthorization of the channel.[3]

Alternative 2 includes interim exposure reduction measures that would be implemented to reduce human consumption of contaminated fish and crab during implementation of the remedial action and the subsequent recovery period of the LPR. These measures include a fish exchange program and measures to reduce the population of carp (an invasive species in the LPR), which generally have the highest concentrations of 2,3,7,8-TCDD and PCBs. The exposure reduction measures would be implemented prior to or concurrent with the sediment cleanup and would remain in effect until risk-based RAOs are achieved.

A summary of the main elements of each remedial alternative, other than Alternative 1, is provided in Table ES-2.

EVALUATION OF THE ALTERNATIVES

Each alternative was evaluated according to the remedy evaluation criteria specified by EPA and the NCP. Each alternative must meet two threshold criteria—overall protection of human health and the environment and compliance with ARARs—to be eligible for selection as EPA's preferred alternative. Five balancing criteria are then applied as a framework to assess tradeoffs among the long-term and short-term effectiveness; reduction in contaminant toxicity, mobility, or volume through treatment; implementability; and cost of each alternative. The final two criteria address state and community acceptance. These are considered modifying criteria and are assessed by EPA, subsequent to the feasibility study, based on consideration of state and public comment on EPA's proposed plan for remedial action. The following discussion addresses four criteria that highlight the differences among the alternatives; all of the criteria are evaluated in the feasibility study.

Protection of Human Health and the Environment

Alternative 2 provides the best overall protection of human health and the environment, achieving the RAOs in a relatively short time frame (within 10 years after initiation of remedial construction). Surface area-weighted concentrations (SWAC) of TCDD will be reduced by

[3] The future commercial demand in the LPR that would support the need for navigation channel deepening is highly uncertain. The U.S. Army Corps of Engineers (USACE) has not performed a cost-benefit analysis for reestablishment of the navigation channel, as would be required for consideration of congressional funding for federal projects under the Water Resources Development Act.

approximately 80 percent over the same time frame (Figure ES-2), following which natural recovery of the top several centimeters of sediment will continue. Site-wide surficial sediment SWAC meets the PRG for direct contact throughout the 30-year projection period. Protection of human health for direct contact risks is achieved under Alternative 2 through the targeted removal of high concentration surficial sediment. Alternative 2 (which includes exposure reduction measures) is the only alternative that achieves EPA's target cancer risk range for human exposures to 2,3,7,8-TCDD from fish consumption (Figure ES-3), under the EPA-directed RME assumptions used in the BHHRA. Surficial sediment 2,3,7,8-TCDD SWAC is projected to be below the ecological sediment PRG. Alternative 2 also includes provisions for post-remediation monitoring and use of adaptive management to re-evaluate the remedy in the event that risk reduction targets are not achieved.

Alternative 3 is not expected to provide overall protection of human health for the entire 17.4-mile LPRSA; specifically, Alternative 3 provides less protection of human health and the environment and does not achieve the RAOs. Although Alternative 3 involves a large volume of sediment removal in the lower eight miles of the river, 48 percent of the removal volume is associated with navigational dredging that does not directly address protection of human health and the environment. As Alternative 3 only actively addresses RM 0 to 8.3, surface sediment with elevated COC concentration are left behind in the upstream portion of the river. In addition, the larger removal volume will result in greater resuspension of dredge residuals that contribute to elevated fish and crab tissue concentrations for the duration of the construction.

In contrast to the 7 year implementation period and approximately 80 percent reduction in SWAC under Alternative 2, Alternative 3 will reduce 2,3,7,8-TCDD site-wide SWAC by only 70 percent and will require approximately 24 years to perform. Although Alternative 4 is predicted to achieve a somewhat greater reduction in surficial sediment concentrations than Alternative 2 (88 percent reduction in 2,3,7,8-TCDD SWAC), it will take approximately 20 years longer to attain these reductions, during which time the fish and crab tissue concentrations are projected to remain elevated due to resuspension of dredge residuals. Achieving the RAOs is uncertain due to the very long implementation time for these alternatives.

Concentrations of tetrachlorobiphenyls[4] (tetra-CB) also decline for all alternatives, with a more rapid decline for Alternative 2 compared with Alternatives 3 and 4 (Figure ES-2); tetra-CB concentrations do not decline as much as 2,3,7,8-TCDD concentrations, as background conditions influence the recovery of PCBs. Total PCB fish tissue concentrations are within the range of background and the crab tissue PRG is achieved. Alternative 2 is also expected to be protective of ecological receptors; fish tissue concentrations of total PCBs are projected to be below the applicable PRGs following remedy implementation.

[4] Tetra-CB is well correlated to total PCBs in both sediment and tissue in the 17-mile remedial investigation data and is used as surrogate for total PCBs in the contaminant fate and transport and bioaccumulation modeling, because total PCBs cannot be modeled as a single contaminant.

Recovery of tissue concentrations following remediation is projected to reduce human health cancer risk from fish and crab consumption. Only Alternative 2 (which includes exposure reduction measures) achieves EPA's target cancer risk range for human exposures to 2,3,7,8-TCDD from fish consumption (Figure ES-3), under the EPA-directed RME assumptions used in the BHHRA. Alternative 4 approaches the target risk range following the 27-year construction period, but does not achieve it in the 30-year projection period evaluated in the feasibility study. Post-remediation total PCB concentrations in fish tissue are projected to be within the background range for all fish species evaluated under Alternative 2. Under Alternatives 3 and 4, total PCB concentrations in fish tissue are also within the background range, but the concentration reductions are smaller in magnitude and take longer to achieve than under Alternative 2. None of the alternatives, however, achieve the target cancer risk range for exposure to total PCBs from fish consumption, under the EPA-directed RME assumptions used in the BHHRA, due to the influence of regional background conditions on total PCB concentrations in fish tissue (Figure ES-3).

For crab consumption, cancer risks from 2,3,7,8-TCDD approach the upper end of the target risk range for Alternatives 2 and 4 following the completion of construction. Due to the targeted removal of high concentration areas and shorter construction time frame under Alternative 2, the decline in crab tissue concentration is expected to occur more rapidly than under Alternative 4. Crab consumption cancer risks for 2,3,7,8-TCDD remain above the target range for Alternative 3. For total PCBs, all of the alternatives result in crab tissue concentrations within EPA's target cancer risk range.

Alternatives 2 and 4 are expected to eliminate any unacceptable risk to human health from direct contact with sediment. While Alternative 3 may achieve this within the area of active remediation downstream of RM 8.3, it will leave some areas of accessible surface sediment with elevated contaminant concentrations in upstream reaches.

Short-Term Effectiveness

Short-term effectiveness is evaluated based on the impacts on human health and the environment during active remediation. These impacts are proportional to the construction duration and volume of dredged material under each alternative. Due to the long durations of all the active alternatives, these "short-term" impacts will continue for many years (7 years under Alternative 2, 24 years under Alternative 3, and 27 years under Alternative 4). Alternatives 3 and 4, which emphasize bank-to-bank sediment removal and have the longest construction durations, have greater short-term impacts in all respects than Alternative 2, which relies on a targeted approach.

Community quality-of-life impacts will include increased traffic disruptions, air emissions, noise, light pollution, and restrictions to river use. For example, local impacts from even a single bridge opening can be substantial, causing vehicle backups that will impact many local and regional roads and result in traffic congestion that could take between one-half to two hours to dissipate, with cumulative driver and passenger delays in the hundreds of hours at each bridge. Openings of multiple, closely-spaced low-clearance bridges (e.g., the Bridge Street and Clay Street Bridges in Newark) will compound these delays, associated economic losses, and air quality impacts from idling vehicles.

Regarding environmental impacts, Alternatives 3 and 4, with larger footprints of dredging and capping, will increase the areal extent and duration of damage to the existing benthic community and other resident aquatic life compared to Alternative 2. Similarly, Alternatives 3 and 4 will increase contaminant releases caused by sediment resuspension during dredging and capping, with an associated increase in concentrations of bioaccumulative chemicals in fish and crab tissue. Energy consumption and air emissions will be proportional to the dredged volume for each alternative, and will be greater for off-site transportation and disposal of dredged materials than for disposal in a CAD in Newark Bay.

Implementability

There will be significant technical and administrative challenges to implementing any of the active remedies evaluated in this feasibility study. The likelihood of technical problems and schedule delays increases in direct proportion to duration and complexity of the alternatives. The RM 10.9 and Phase 1 Removal Actions performed in the LPRSA provided site-specific experience that is informative and relevant to the evaluation of remedial alternatives for the feasibility study. Multiple challenges were encountered during the planning and implementation of the prior removal actions. Similar challenges can be expected for any sediment removal action performed in the LPRSA, and planning of future removal activities must consider these experiences. In addition, The National Marine Fisheries Service has established a fish migration window on the LPR from March 1 to June 30 each year. Dredging restrictions anticipated to be imposed during this period will significantly increase construction durations.

Alternatives 3 and 4, with larger removal components have more complex technical and administrative implementability issues than Alternative 2 due to their much larger geographic and temporal scale and the increased complexity of dredging and DMM associated with larger sediment removal volumes and footprints. Alternatives 3 and 4, which involve larger removal and cap material volumes, require two to three times as many bridge openings, barge and truck trips, and rail use as Alternative 2. Alternatives 3 and 4 also impose considerably greater challenges and limitations associated with implementing dredging and capping around utility crossings, bridges, and shoreline structures; and thus have a comparatively greater potential for problems and delays than does Alternatives 2, having a smaller active footprint, smaller removal volumes, and a shorter construction period.

Disposal of dredged material in open water CAD cells has been practiced for many years for both navigational and environmental dredging projects. A CAD cell has been used in Newark Bay by USACE for New York/New Jersey harbor navigation dredging and deepening. After 15 years of use, the Newark Bay CAD was closed in 2012 after reaching capacity. A CAD facility has been determined by EPA to be a technically feasible, highly reliable, and cost-effective disposal option for the sediment removed from the LPRSA. However, it is anticipated that administrative challenges from the State of New Jersey and other parties to this disposal option will be formidable, requiring extensive outreach and coordination with the EPA, the State of New Jersey, the Natural Resource Trustees, the public, and other stakeholders.

Cost

A summary of the estimated cost for each of the remedial alternatives is presented in Table ES-3. For the off-site disposal scenario (Scenario A), the costs are largely proportional to the total removal volume, ranging from $726 million (714,000 cubic yard removal volume) for Alternative 2 to $2,652 million for Alternative 4 (4,496,000 cubic yard removal volume). For the CAD option (Scenario B), remedial costs are largely driven by dredge volume; dredge material management costs are significantly less due to the elimination of material processing, off-site transportation, and disposal. Selection of the CAD option would reduce the overall costs of Alternatives 2 and 4 by $243 million and $1,100 million, respectively.

SUMMARY OF THE COMPARATIVE ANALYSIS

A graphical summary of the comparative analysis of alternatives is provided in Figure ES-4, along with the results of a scoring analysis performed to compare the overall rankings of the remedial alternatives. These relative rankings allow for distinction of similarities and dissimilarities between the alternatives. The balancing criteria, except for cost, were scored on a scale of 1 to 5. The rating scale is a linear relationship, with minimum performance given a rating of 1 and maximum performance given a rating of 5. The resulting cumulative scores are evaluated against the cost of the alternatives.

Alternative 1 fails to meet CERCLA threshold criteria but was retained for comparative purposes as the no-action alternative.

Alternative 2 receives the highest ranking because it rapidly achieves RAOs through a combination of active remediation, MNR, and institutional controls. Additionally, among the active alternatives, Alternative 2 is ranked highest for technical and administrative feasibility, has the least short-term impacts, affords greater flexibility to adapt to changed conditions and new information as remediation proceeds, and offers greater cost-effectiveness than Alternatives 3 and 4.

In contrast, Alternatives 3 and 4, which incorporate a much larger footprint of active remedial measures, do not score as highly as Alternative 2 due to:

- Lower degrees of overall protectiveness of human health and the environment, due to incomplete attainment of RAOs and/or longer time frames required for RAOs to be met

- Greater impacts to workers, community, and the environment during implementation
- Greater complexity and uncertainty in remedy implementation
- Limited opportunities, in the event that goals are not achieved, to gain information and adapt the remedy over time.

The evaluation of remedial costs and selection of a final remedy must consider the statutory requirements of the NCP, which states, *"Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in 40 CFR § 300.430(f)(1)(ii)(A) and (B)"*; a remedy is deemed cost-effective *"if its costs are proportional to its overall effectiveness"* (Code of Federal Regulations [CFR]: 40 CFR §300.430(f)(1)(ii)(D)). In the feasibility study, the CERCLA primary balancing criteria were weighed to identify the key tradeoffs among the remaining alternatives in terms of their short- and long-term effectiveness, implementability, cost, and ability to meet the programmatic expectation under CERCLA for remedies that utilize treatment and provide for permanent solutions to the maximum extent practicable (40 CFR § 300.430(f)(1)(ii)(E)). To assess the cost-effectiveness of the remedial alternatives, the remedial costs can be compared to the cumulative benefits for each alternative, where the benefits are represented by the CERCLA criteria rankings. As indicated in Figure ES-5, the cumulative rankings are similar for Alternatives 1, 3, and 4 (scores ranging from 8 to 11), and greatest for Alternative 2 (score of 17). The remedial costs of the three active alternatives (2, 3, and 4) are not well-correlated with the rankings. Alternatives 3 and 4 have relatively lower rankings compared to Alternative 2, but their costs are approximately 4 times greater. This relationship illustrates that Alternatives 3 and 4 are not cost-effective relative to Alternative 2.

Cost-effectiveness can be further evaluated by comparing the reduction in human health risk from fish consumption to the estimated cost for each alternative. A comparison of the risk reduction associated with consumption of fish containing 2,3,7,8-TCDD and total PCBs is presented in Figure ES-6. As indicated, the projected reduction in 2,3,7,8-TCDD risk is 96 percent for Alternative 2, 75 percent for Alternative 3, and 91 percent for Alternative 4. Similarly, the total PCB risk reduction is 81 percent for Alternative 2, 66 percent for Alternative 3 and 71 percent for Alternative 4. By contrast, remedial costs for Alternatives 3 and 4 are approximately 4 times greater than the remedial cost for Alternative 2. Similar to the above assessment of CERCLA criteria, while significantly more costly, Alternatives 3 and 4 do not yield additional risk reduction, compared with Alternative 2.

IDENTIFICATION OF A RECOMMENDED ALTERNATIVE

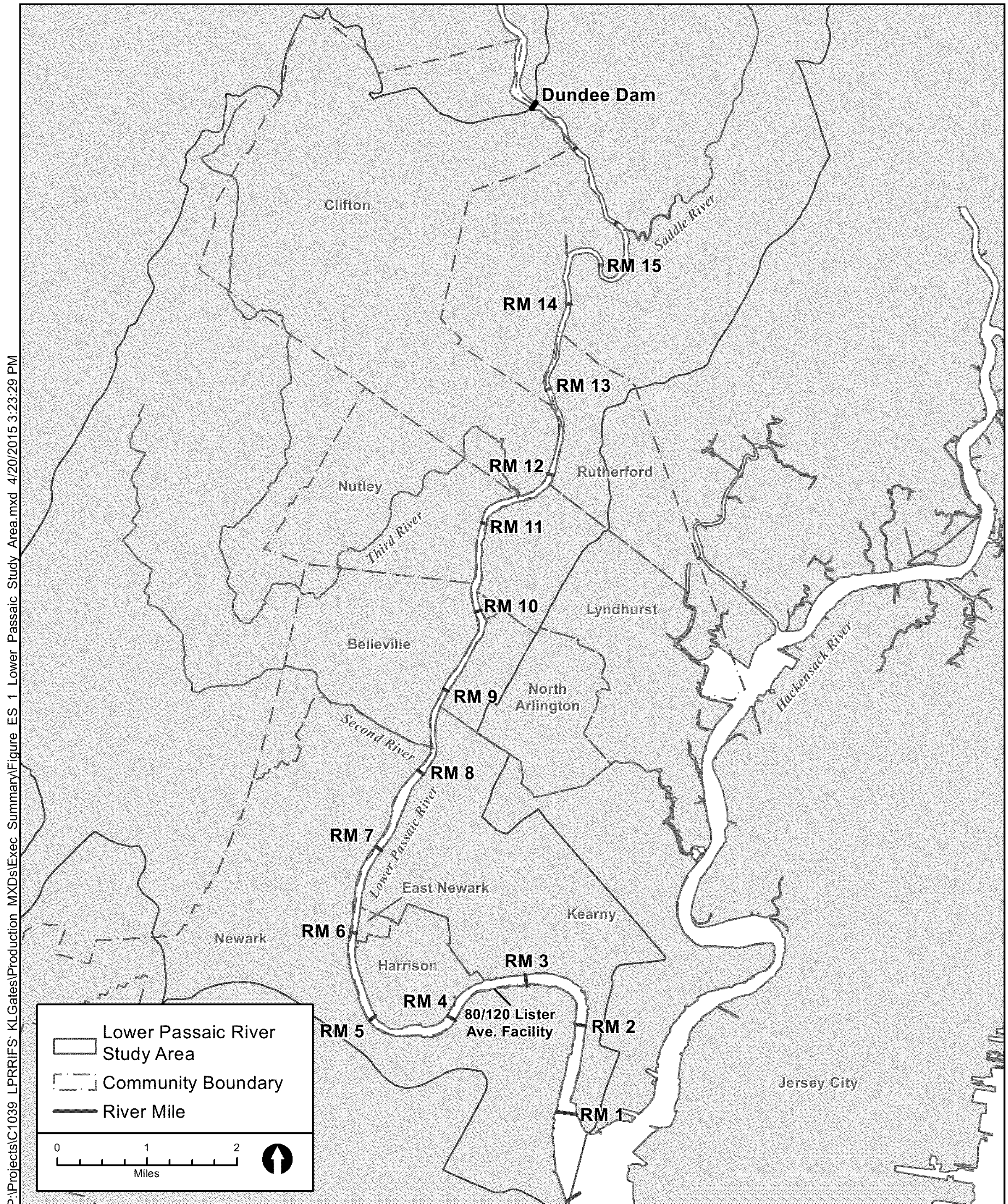
Overall, Alternative 2, which is protective of human health and the environment and complies with ARARs, achieves equal or greater benefits relative to other alternatives more rapidly and cost-effectively, and with fewer adverse short-term impacts to workers, the community, and the environment. Targeted remedial efforts focus on addressing the most contaminated areas of the entire 17.4-mile LPRSA, which, combined with exposure reduction measures during and after the cleanup, reduce risks much faster than Alternatives 3 and 4. Integrated MNR and adaptive management ensure long-term protectiveness and permanence of the remedy. By addressing the highest near surface concentrations of 2,3,7,8-TCDD within a relatively short time frame, human health risks from the consumption of contaminated fish tissue are reduced to within acceptable risk levels (characterized by EPA's target excess cancer risk range of 1×10^{-4} to 1×10^{-6}) much sooner than Alternative 3 or 4. Therefore, Alternative 2 is the recommended remedial alternative for the LPRSA.

Alternative 2 offers the following benefits:

- Short-term human health risks are immediately reduced by implementing exposure reduction measures.
- Achieves RAOs within 10 years of initiation of remedial construction.
- Alternative 2 remedial activities can be completed sooner, accelerating ecological restoration opportunities in the entire LPRSA.
- Short-term risks to workers are relatively low due to the short duration of active remedy construction. The estimated 7-year construction period for Alternative 2 is less than 30 percent of the estimated construction periods for Alternatives 3 and 4 (24 and 27 years, respectively).
- Community and environmental impacts are relatively low due to the shorter duration of active remedial construction activities. Given the complexities associated with sediment removal in the LPRSA, any reduction in construction duration and intensity will significantly reduce the risks to the community and adverse impacts to quality of life during remedy construction.
- The targeted approach for Alternative 2 involves much smaller sediment removal and capping volumes and can be implemented far more readily than Alternative 3 or 4, mitigating to some degree the significant implementation challenges and constraints posed by conditions on the LPR (e.g., numerous utility crossings, shoreline structures, debris, navigational constraints, bridge opening requirements, and transportation and disposal requirements for dredged materials).
- There is low potential for re-exposure of remaining subsurface contamination given the overall stability of the sediment bed. In addition, by addressing areas within the 17.4-mile LPRSA containing the highest near surface concentrations, the potential for recontamination from internal sources is significantly reduced.
- Coupled with MNR, adaptive management provides a means to effectively manage residual risks and uncertainties by focusing ongoing monitoring to assess and optimize the remedy over time and to assess the effectiveness of upland and/or upstream source control efforts undertaken by others in preventing recontamination from external sources. Adaptive management allows the remedy to be implemented in a systematic

manner to address uncertainties, resulting in efficient use of resources and reduced impacts to the surrounding community and businesses.

- Potential future use restrictions (e.g., anchoring) related to cap areas are manageable and do not preclude future dredging in the FNC.



Note: River miles in USACE system

Figure ES-1.
Lower Passaic River Study Area

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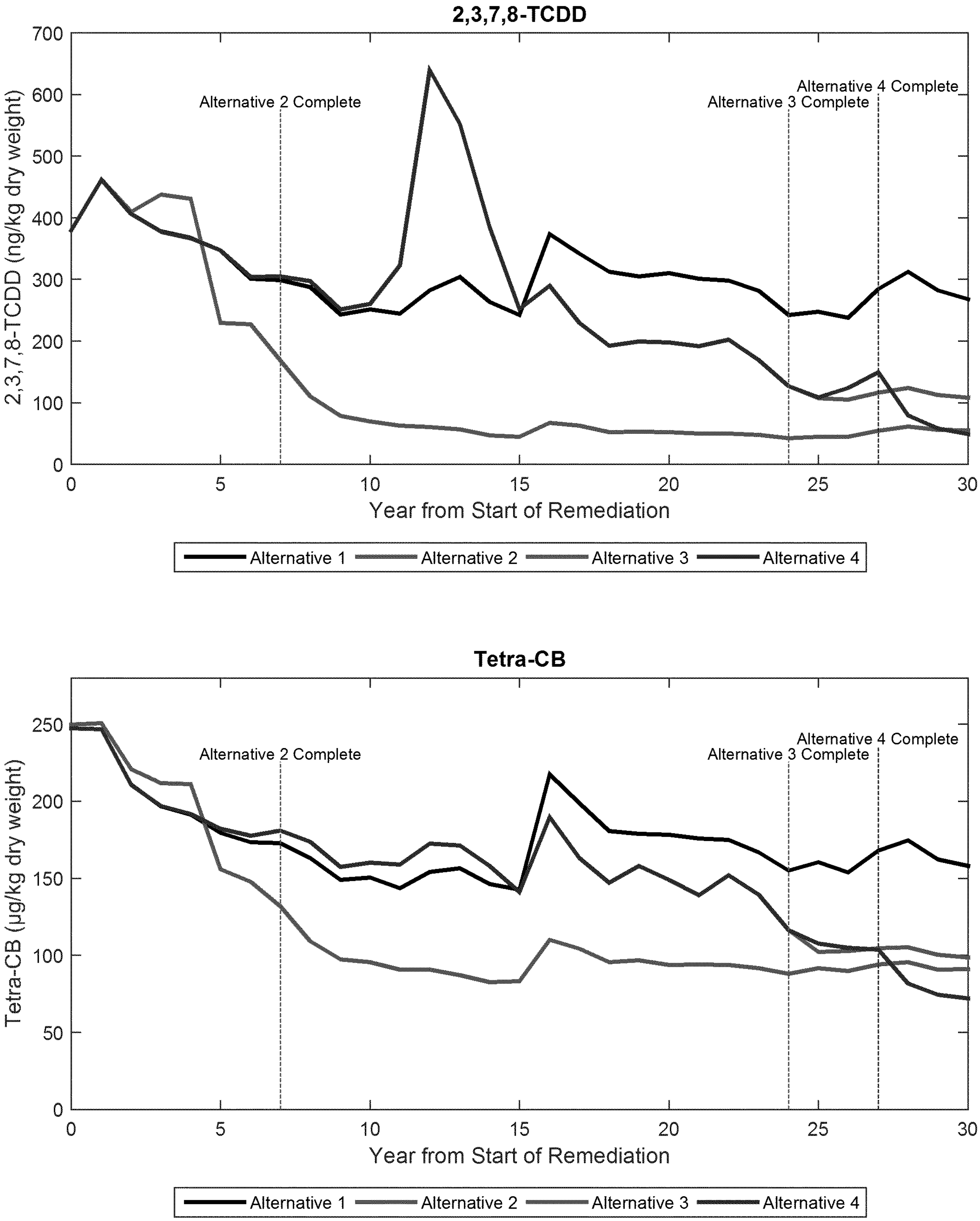

Projections source:
CFT – AQEA (11/14/14)

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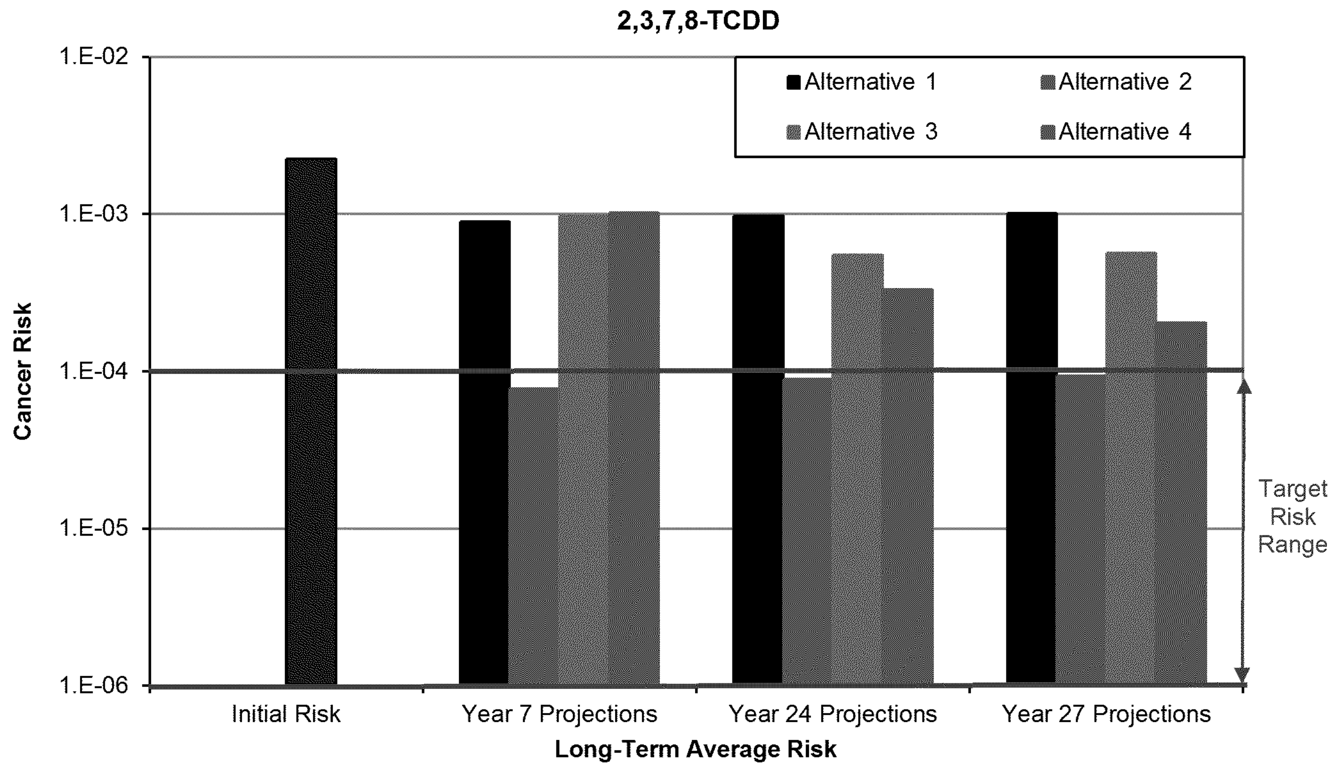
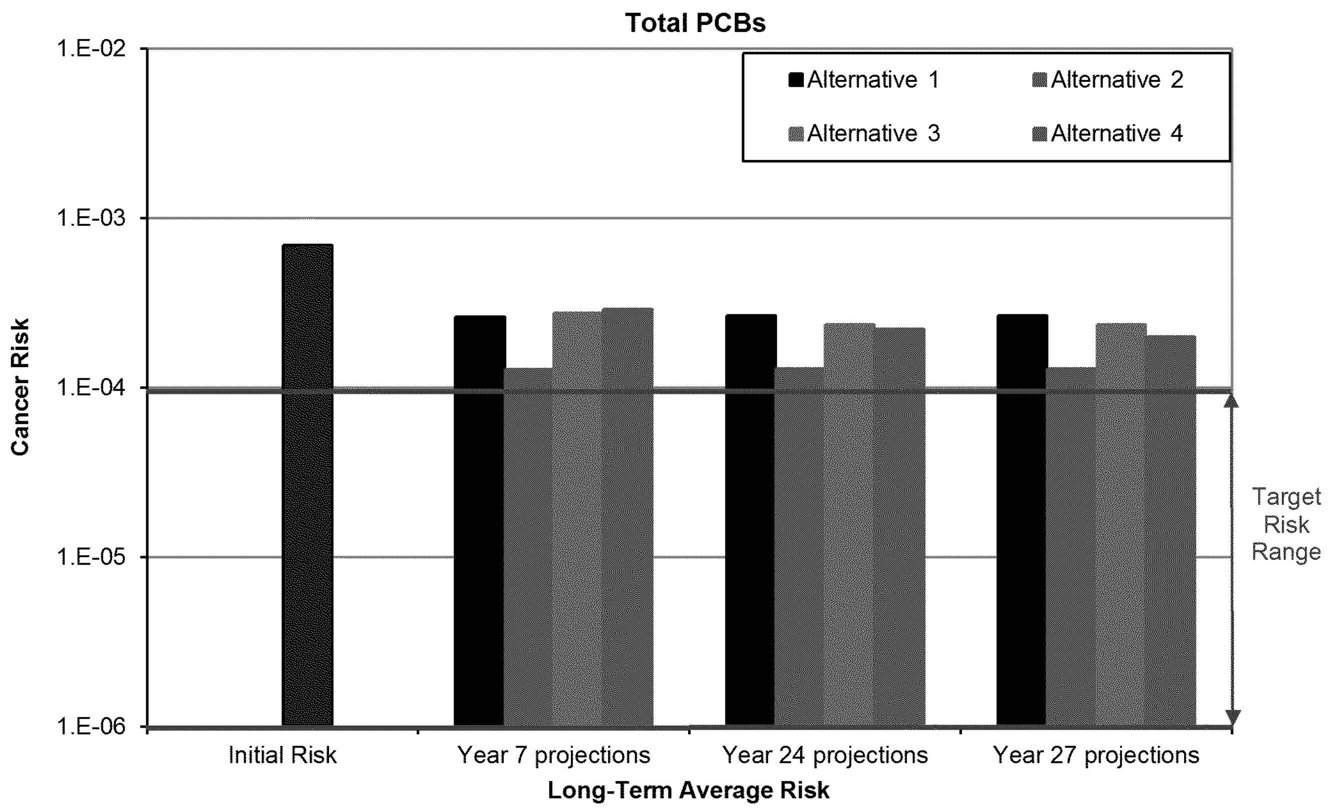
Note: Projections for Alternatives 3 and 4 are coincident until approximately year 24

Figure ES-2.
Projected Surficial Sediment
Surface Area-Weighted Average Concentrations –
2,3,7,8-TCDD and Tetra-CBs (0 to 2 cm depth interval)





Projections source:
CFT - AQEA (11/14/14), FWM - Windward (2/6/15), Risk - AECOM (2/11/15)

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Figure ES-3.
Projected Human Health Residual Fish Consumption Cancer Risk for 2,3,7,8-TCDD and Total PCBs

		Alternative 1	Alternative 2	Alternative 3	Alternative 4
THRESHOLD	1. Overall Protection of Human Health and the Environment	No	Yes	No	Yes
	2. Compliance with ARARs	No	Yes	Yes	Yes
BALANCING	3. Long-Term Effectiveness and Permanence	●	◉	◒	◉
	4. Reduction of Toxicity, Mobility, or Volume through Treatment	●	◓	○	◓
	5. Short-Term Effectiveness	◒	◓	◒	●
	6. Implementability	◉	◓	●	●
OVERALL SCORE (Sum of Individual Balancing Criteria Rankings)[a]		**9**	**17**	**8**	**11**
Cost (Off-Site Disposal)		**$28 M**	**$726 M**	**$2,550 M**	**$2,652 M**
Cost (Confined Aquatic Disposal [CAD])		**$28 M**	**$483 M**	**$1,373 M**	**$1,552 M**

◉ ◓ ○ ◒ ●

Better < < < > > > Worse

Notes:
[a]The balancing criteria were scored on a linear scale of 1 to 5, with minimum performance given a rating of 1 and maximum performance given a rating of 5.
M = million

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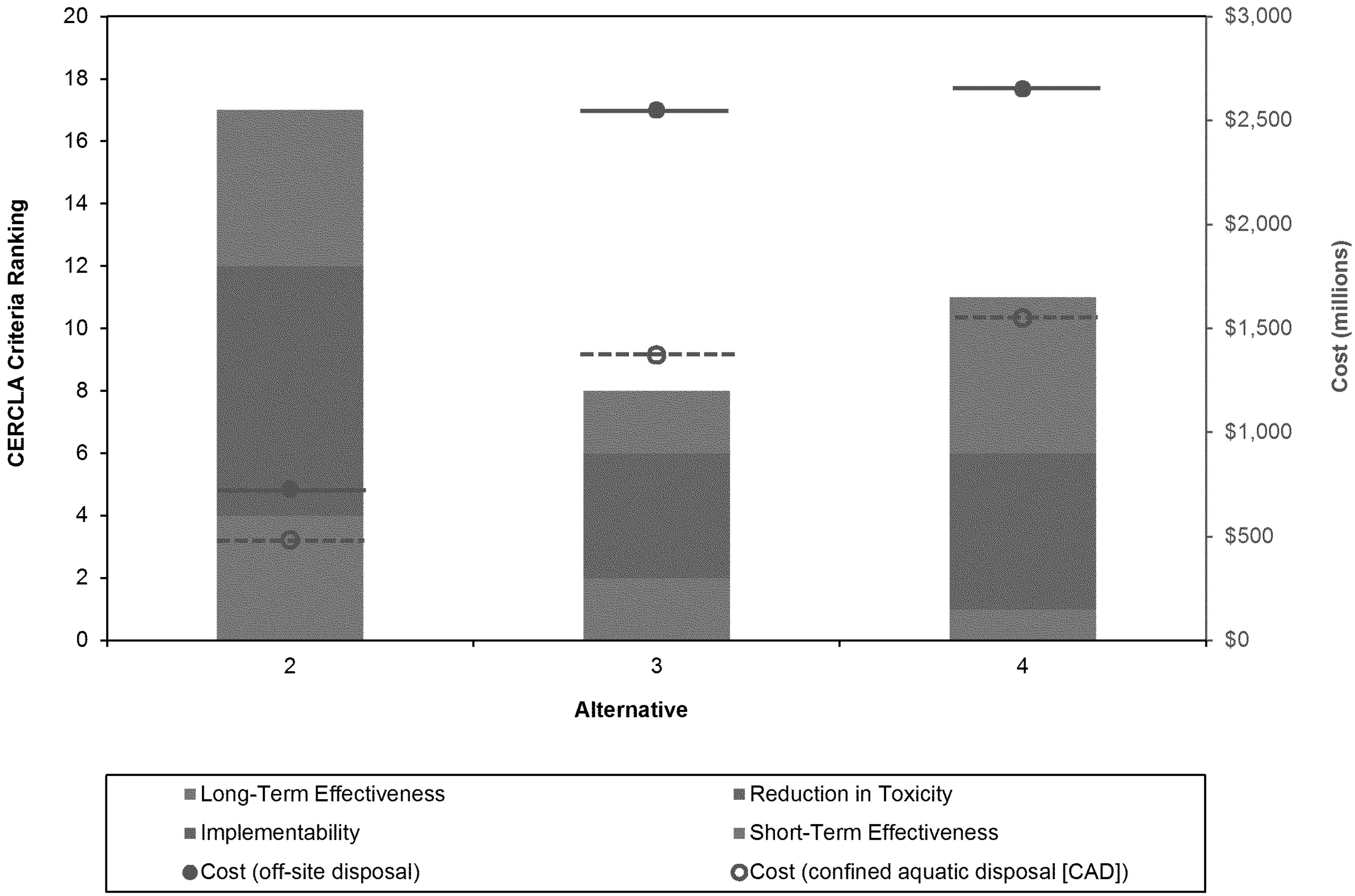
Figure ES-4.
Summary of the Comparative Evaluation of Alternatives



Note:
The balancing criteria were scored on a linear scale of 1 to 5, with minimum performance given a rating of 1 and maximum performance given a rating of 5.

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Figure ES-5.
CERCLA Criteria Ranking versus Cost

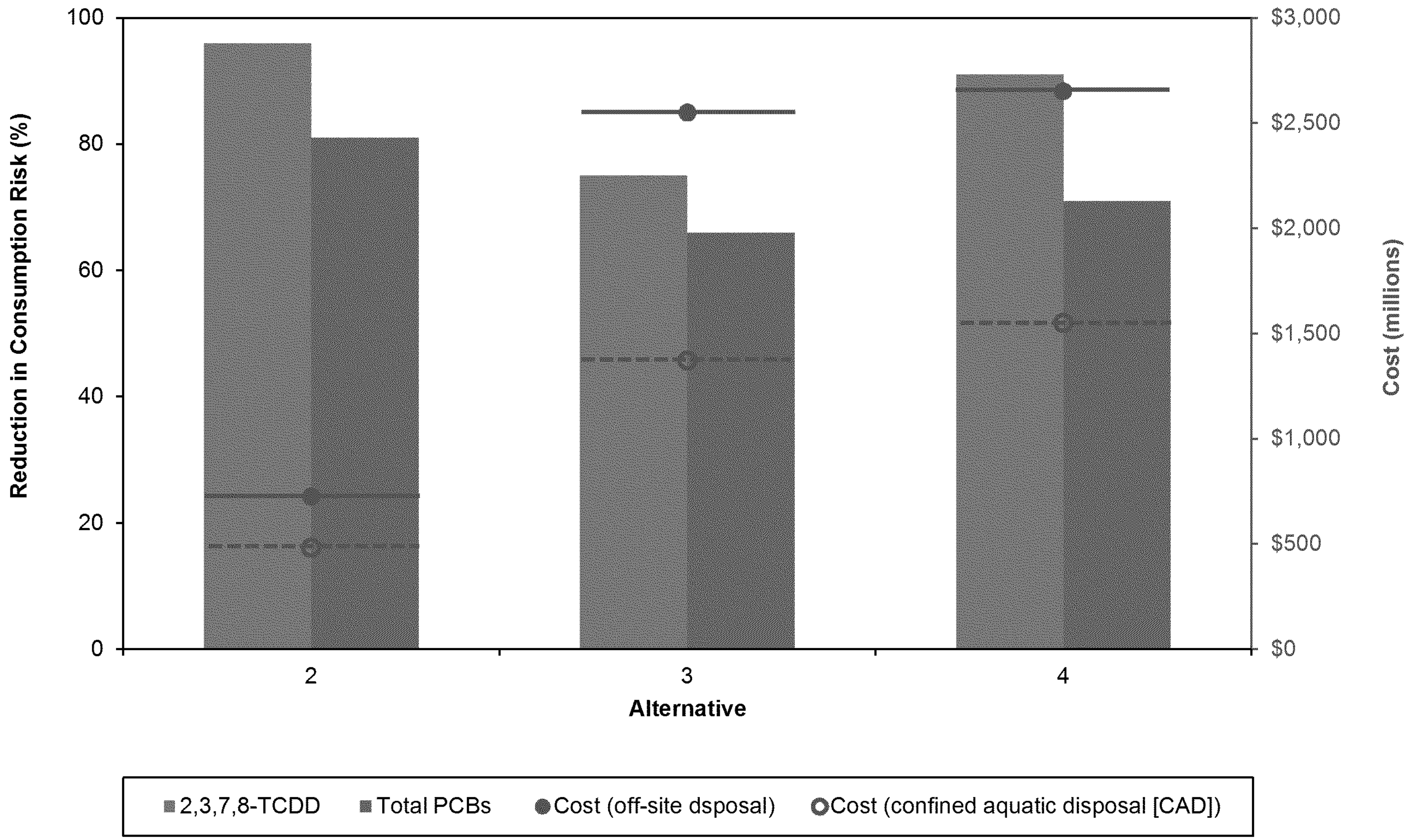

Figure ES-6.
Risk Reduction from Fish Consumption versus Cost

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Table ES-1. Preliminary Remediation Goals and Interim Targets for 2,3,7,8-TCDD and Total PCBs

Chemical	Receptor	Medium	Type	Value	Units
2,3,7,8-TCDD	Adult angler	Fish tissue	Background (low)[a]	0.1	ng/kg ww
	Adult angler	Fish tissue	Background (high)[a]	2	ng/kg ww
	Adult angler	Fish tissue	Baseline PRG (1E-4 cancer)[b]	4	ng/kg ww
	Adult angler	Fish tissue	SSPRG (noncancer)[f]	12	ng/kg ww
	Adult angler	Fish tissue	SSPRG (1E-4 cancer)	71	ng/kg ww
	Adult angler	Fish tissue	Interim target: 1 meal/month[c]	20	ng/kg ww
	Adult angler	Fish tissue	Interim target: 6 meals/year[c]	41	ng/kg ww
	Adult angler	Crab tissue[d]	Background[a]	3	ng/kg ww
	Adult angler	Crab tissue[d]	Baseline PRG (1E-4 cancer)[b]	7	ng/kg ww
	Adult angler	Crab tissue[d]	SSPRG (noncancer)[f]	35	ng/kg ww
	Child swimmer/wader	Surface sediment	Baseline PRG (noncancer)[b]	2,500	ng/kg dw
	Adult worker	Surface sediment	SSPRG (noncancer)[f]	11,000	ng/kg dw
	Fish	Fish (whole body)	Ecological PRG	140	ng/kg ww
	Spotted sandpiper	Surface sediment	Ecological PRG	750	ng/kg dw
Total PCBs	Adult angler	Fish tissue	Background (low)[e]	0.1	mg/kg ww
	Adult angler	Fish tissue	Background (high)[e]	2.1	mg/kg ww
	Adult angler	Fish tissue	SSPRG (1E-4 cancer)[a,f]	3.5	mg/kg ww
	Adult angler	Crab tissue[d]	Background [a]	0.16	mg/kg ww
	Adult angler	Crab tissue[d]	Baseline PRG (1E-4 cancer)[b]	0.5	mg/kg ww
	Fish (ecological risk)	Fish (whole body)	Ecological PRG	6.3	mg/kg ww

Notes:

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo- *p*-dioxin
dw = dry weight
PCB = polychlorinated biphenyl
PRG = preliminary remediation goal
SSPRG = site-specific PRG
ww = wet weight

[a] Risk-based threshold concentrations (RBTCs) based on 10^{-6} and 10^{-5} target risk levels for cancer risk and hazard quotient of 1 for noncancer risk are below or within background range.

[b] Baseline PRGs derived using reasonable maximum exposure (RME) parameters as directed by EPA for the BHHRA.

[c] Interim target for species other than carp. Proposed interim targets for carp are 61 to 320 ng/kg ww, which would achieve the 1E-4 risk level with reasonable maximum exposure assumptions using a consumption rate of four meals per year (61 ng/kg), or the 1E-4 risk level with central tendency exposure assumptions using a consumption rate of four meals per year (320 ng/kg).

[d] Crab tissue diet assumes consumption of muscle and hepatopancreas.

[e] All baseline RBTCs are below or within background range.

[f] SSPRGs derived using RME parameters developed by the Cooperating Parties Group for the site-specific human health risk assessment (see Appendix D.2).

Table ES-2. Description of the Lower Passaic River Study Area Remedial Alternatives

	Alternative 2 Targeted Remedy	Alternative 3 EPA FFS Alternative 3	Alternative 4 Composite of Alternatives 2 and 3
Summary description	- Targeted removal of sediment within mapped areas from RM 0 to 14.6 with 2,3,7,8-TCDD surface sediment concentrations exceeding a remedial action level (RAL)[a] of 500 ng/kg - Capping of remaining legacy sediments at depth - MNR of areas not actively remediated and adaptive management to address areas that do not recover within an acceptable time frame - Exposure reduction measures to reduce human consumption of contaminated fish and crab	- Bank-to-bank dredging to facilitate placement of an engineered cap from RM 0.0 to 8.3 - Restoration of the federal navigation channel from RM 0.0 to 2.2 - MNR upstream of RM 8.3	- RM 0.0 to 8.3: Identical to Alternative 3, consisting of bank-to-bank dredging and capping and provisions for restoration of the navigation channel between RM 0.0 and 2.2 - RM 8.3 to 14.6: Dredging and capping of the target areas identified in Alternative 2 - MNR of areas upstream of RM 8.3 that are not actively remediated
Dredged material management	- <u>Scenario A:</u> Sediment dewatering with treatment of effluent at an upland sediment processing facility, followed by off-site transportation and disposal out of state - <u>Scenario B:</u> Placement of sediment in a confined aquatic disposal facility to be constructed in Newark Bay	Same as Alternative 2	Same as Alternative 2
Duration (years)	7	24	27
Dredge volume (cy)	714,000	4,310,000	4,500,000
Cap volume (cy)	714,000	2,630,000	2,830,000
Active remedial footprint (acres)	148	661	701
MNR footprint (acres)	819	306	266

Notes:

cy = cubic yards
EPA = U.S. Environmental Protection Agency
FFS = focused feasibility study
MNR = monitored natural recovery
RM = river mile
TBD = to be determined
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin

[a] RALs define the concentration above which active remedial measures (i.e., dredging or capping) would be taken under a given remedial alternative to reduce concentrations in sediment sufficiently to reach a target risk level within a reasonable time frame. Additional discussion of RALs is provided in the feasibility study.

Table ES-3. Summary of Costs for Remedial Alternatives

	Alternative 1	Alternative 2		Alternative 3		Alternative 4	
		Off-Site Disposal	CAD	Off-Site Disposal	CAD	Off-Site Disposal	CAD
Direct capital ($M)	0	567	274	2,430	1,084	2,568	1,182
Indirect capital ($M)	0	127	166	281	334	296	359
Total capital ($M)	0	694	439	2,711	1,418	2,863	1,542
Annual OMM ($M/year)	1.1	3.0	3.1	6.7	7.0	6.9	7.1
Present value ($M) [a]	28	726	483	2,550	1,373	2,652	1,552

Notes:

Estimates represent feasibility level of accuracy (+50/-30%).

Direct capital and annual OMM costs include 25% contingency.

Annual OMM costs are assumed to begin in Year 6 of construction and continue for 30 years past completion of construction.

CAD = confined aquatic disposal

M = million

OMM = operation, maintenance, and monitoring

[a] 1.4% discount rate